

WHAT IS CLAIMED IS:

1 1. A method for depositing an undoped silicon oxide film on a substrate
2 disposed in a process chamber, the method comprising:
3 flowing a process gas comprising SiF₄, H₂, a silicon source, and an oxidizing
4 gas reactant into the process chamber;
5 forming a plasma having an ion density of at least 10¹¹ ions/cm³ from the
6 process gas; and
7 depositing the undoped silicon oxide film over the substrate with the plasma
8 using a process that has simultaneous deposition and sputtering components, wherein a
9 temperature of the substrate during such depositing is greater than 450°C.

1 2. The method recited in claim 1 wherein the temperature of the substrate
2 during such depositing is substantially between 500 and 800°C.

1 3. The method recited in claim 1 wherein the temperature of the substrate
2 during such depositing is substantially between 700 and 800°C.

1 4. The method recited in claim 1 wherein the silicon source comprises
2 SiH₄.

1 5. The method recited in claim 4 wherein a ratio of a flow rate of SiF₄ to
2 the process chamber to a flow rate of SiH₄ to the process chamber is substantially between
3 0.5 and 3.0.

1 6. The method recited in claim 4 wherein the oxidizing gas reactant
2 comprises O₂.

1 7. The method recited in claim 6 wherein a flow rate of H₂ to the process
2 chamber is less than 1500 sccm.

1 8. The method recited in claim 6 wherein a flow rate of O₂ to the process
2 chamber is greater than a factor times a sum of the flow rate of SiF₄ and the flow rate of SiH₄
3 to the process chamber, the factor being less than about 1.8 for a flow rate of H₂ to the
4 process chamber less than about 300 sccm and being between about 1.8 and 3.0 for a flow
5 rate of H₂ to the process chamber greater than about 300 sccm.

1 9. The method recited in claim 1 wherein the process gas further
2 comprises an inert gas.

1 10. The method recited in claim 9 wherein the inert gas comprises He.

1 11. The method recited in claim 1 wherein the undoped silicon oxide film
2 is a first portion of an undoped silicon oxide layer, the method further comprising:
3 depositing a second portion of the undoped silicon oxide layer over the
4 substrate; and
5 etching one of the first and second portions of the undoped silicon oxide layer
6 between depositing the undoped silicon oxide film and depositing the second portion of the
7 undoped silicon oxide layer.

1 12. The method recited in claim 11 wherein depositing the second portion
2 of the undoped silicon oxide layer is performed before the etching and depositing the
3 undoped silicon oxide film is performed after the etching.

1 13. The method recited in claim 11 wherein depositing the second portion
2 of the undoped silicon oxide layer comprises:
3 flowing a second process gas comprising SiF_4 , H_2 , the silicon source, and the
4 oxidizing gas reactant into the process chamber; and
5 forming a second plasma having an ion density of at least 10^{11} ions/cm³ from
6 the second process gas,
7 wherein a temperature of the substrate during such depositing the second
8 portion of the undoped silicon oxide layer is greater than 450°C.

1 14. A method for depositing an undoped silicon oxide film on a substrate
2 disposed in a process chamber, the substrate having a trench formed between adjacent raised
3 surfaces, the method comprising:
4 flowing a process gas comprising SiF_4 , H_2 , SiH_4 , and O_2 into the process
5 chamber, wherein a ratio of a flow rate of SiF_4 to a flow rate of SiH_4 is substantially between
6 0.5 and 3.0;
7 forming a plasma having an ion density of at least 10^{11} ions/cm³ from the
8 process gas; and

9 depositing the undoped silicon oxide film over the substrate and within the
10 trench with the plasma using a process that has simultaneous deposition and sputtering
11 components, wherein a temperature of the substrate during such depositing is greater than
12 450°C.

1 15. The method recited in claim 14 wherein the temperature of the
2 substrate during such depositing is substantially between 500 and 800°C.

1 16. The method recited in claim 14 wherein the temperature of the
2 substrate during such depositing is substantially between 700 and 800°C.

1 17. The method recited in claim 14 wherein a flow rate of O₂ to the
2 process chamber is greater than a factor times a sum of the flow rate of SiF₄ and the flow rate
3 of SiH₄ to the process chamber, the factor being less than about 1.8 for a flow rate of H₂ to
4 the process chamber less than about 300 sccm and being between about 1.8 and 3.0 for a flow
5 rate of H₂ to the process chamber greater than about 300 sccm.

1 18. The method recited in claim 14 wherein the process gas further
2 comprises an inert gas.

1 19. The method recited in claim 14 wherein the undoped silicon oxide film
2 is a first portion of an undoped silicon oxide layer, the method further comprising:
3 depositing a second portion of the undoped silicon oxide layer over the
4 substrate and within the trench; and
5 etching one of the first and second portions of the undoped silicon oxide layer
6 between depositing the undoped silicon oxide film and depositing the second portion of the
7 undoped silicon oxide layer.

1 20 . A method for depositing an undoped silicon oxide layer on a substrate
2 disposed in a process chamber, the substrate having a trench formed between adjacent raised
3 surfaces, the method comprising, in the recited order:

4 depositing a first portion of the undoped silicon oxide layer over the substrate
5 and within the trench by forming a high-density plasma that has simultaneous deposition and
6 sputtering components;

7 etching at least part of the first portion of the undoped silicon oxide layer; and

8 depositing a second portion of the undoped silicon oxide layer over the
9 substrate and within the trench by forming a high-density plasma that has simultaneous
10 deposition and sputtering components,
11 wherein depositing at least one of the first portion and the second portion
12 comprises:
13 flowing a process gas comprising SiF₄, H₂, SiH₄, and O₂ into the
14 process chamber;
15 forming the high-density plasma from the process gas; and
16 depositing the at least one of the first portion and the second portion
17 with the plasma at a temperature greater than 450°C.

1 21. The method recited in claim 20 wherein depositing the at least one of
2 the first portion and the second portion comprises depositing the second portion.

1 22. The method recited in claim 20 further comprising:
2 etching at least a part of the second portion of the undoped silicon oxide layer;
3 and
4 depositing a third portion of the undoped silicon oxide layer over the substrate
5 and within the trench by forming a high-density plasma that has simultaneous deposition and
6 sputtering components.

1 23. The method recited in claim 20 wherein the temperature is
2 substantially between 500 and 800°C.

1 24. The method recited in claim 20 wherein the temperature is
2 substantially between 700 and 800°C.

1 25. The method recited in claim 20 wherein a flow rate of O₂ to the
2 process chamber is greater than a factor times a sum of the flow rate of SiF₄ and the flow rate
3 of SiH₄ to the process chamber, the factor being less than about 1.8 for a flow rate of H₂ to
4 the process chamber less than about 300 sccm and being between about 1.8 and 3.0 for a flow
5 rate of H₂ to the process chamber greater than about 300 sccm.

1 26. The method recited in claim 20 wherein the process gas further
2 comprises an inert gas.